# Coordination of Capital Taxation Among a Large Number of Asymmetric Countries

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# Coordination of Capital Taxation Among a Large Number of Asymmetric Countries[¤]

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Abstract

We examine international …scal coordination in a world where markets are integrated but national governments are sovereign. Consequences of the liberalization of the capital market on national …scal policies and possible remedies to resulting ine¢ciencies are analyzed. A simple model, with N countries where competitive …rms produce an homogeneous good using mobile capital and immobile labor is considered. Fiscal competition arises between governments that have to tax capital and labor in order to raise …xed amount of revenue. It is shown that capital mobility improves the capital allocation among countries as it enables capital owners to invest it in the country where capital is scarce. But …scal competition leads to asymmetric capital taxation among countries and thus to a distortion on the international capital market.

Two …scal reforms are considered: the introduction of a minimum capital tax level and the imposition of a tax range, i.e. a minimum plus a maximum capital tax level.

We show that the minimum tax reform is never prefered to …scal competition by all countries while tax range reforms are unanimously accepted when it imposes convergence to the extreme taxes and it does not change the international remuneration of capital.

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## 1. Introduction

The paper tackles the problem of international …scal coordination in a world where markets are integrated but national governments are sovereign. The ongoing globalization movement allows a superior utilization of resources and a better allocation of risks among countries. When markets get more liberalized, national economies become more interdependent. Therefore a government has to take into account the behavior of its trade partners when undertaking local economic policies. It is no longer possible to envisage redistributive policies, the production of public goods or the …scal policy without taking into account its e¤ects on trade or capital ‡ows. A possible consequence of this international interdependence is a downward pressure on the size of the public sector (cfr. Cremer and Al. (1996) for a survey of the literature). This could be viewed as a positive consequence if we consider the government as a growing and ine¢cient Leviathan and a negative one if we envisage a benevolent social planner.

In this paper, we consider the consequences on national …scal policies of the liberalization of the capital market. We consider a simple model, with N countries where competitive …rms produce a homogeneous good using mobile capital and immobile labor. Fiscal competition arises between governments that have to tax capital and labor in order to levy a …xed amount of public money. The capital tax we consider here, as it concerns productive capital, has to be understood as a corporate tax[1].

We show that capital mobility improves capital allocation among countries as it enables capital owners to invest in the country where capital is scarce. But …scal competition leads to asymmetric capital taxation and thus to a distortion of the international capital market. More precisely, at equilibrium, the more a country imports capital, the larger its corporate tax. This is because a country importing capital, by taxing it, has part of its tax burden supported by foreign capital owners. Moreover, by taxing capital, a country depresses the international remuneration of capital and therefore decreases the cost it has to incur for the capital it imports.

The questions raised in this paper are important policy issues. Both the OECD and the European Commission have advocated …scal harmonization; see OECD (1991) and the Ruding Report (1992), in reference to production e¢ciency.

The core of this paper is the analysis of possible remedies to the consequences of …scal competition. We consider two …scal reforms: the introduction of a minimum capital tax level and the imposition of a tax range, i.e. a minimum and a maximum capital tax level[2].

[1] This view is shared by most of the literature, see for instance Person and Tabellini (1992).

[2] The …rst reform has already been used by the European Union to decrease the ine¢ciency

Taking as decision rule unanimity, we show that the minimum tax reform never passes and that tax range reforms are unanimously accepted when it imposes convergence to the extreme of equilibrium taxes.

These reforms have the nice features of being simple, anonymous and of respecting the subsidiary principle.[3] It is anonymous in that it applies in the same way to all countries, i.e. it restricts their strategy set and does not assign a particular tax level to each country. It respects the subsidiary principle in that it leaves to the national level the …scal decision while the supra-national interventions intend to limit ine¢ciencies.

It is possible to interpret this as an attempt to design supra-national (for Europe) or federal (for the Australia, Canada or the US) institutions helping to avoid ine¢ciencies linked to …scal competition. The core of an institution is its jurisdiction and decision rule. The jurisdiction would be the setting of the tax range or of the minimum tax level. We have selected unanimity as decision rule as it is the one used in the European Union on these matters.

Would the model be empirically irrelevant, our policy propositions would be with little interest. In order to convince us of the empirical relevance of the model, we computed correlations between statutory corporate tax levels and the extend of foreign capital ownership for the 14 EU members. This has not to be considered as a rigorous test because the measurements we use are rough estimations: We proxy the extend of the foreign ownership of capital in a country by aggregating its current account balance between 1990 and 1996. We would reject our theory, if we observed a negative correlation between the statutory corporate tax of each country and the ratio between our proxy of foreign ownership of capital and the number of workers. Our sample consists in 14 members of the E U (all except Luxembourg for which we do not have all data) and our data come from the IMF (1998) and the KPMG corporate tax survey 1998. We …nd a signi…cant positive correlation and therefore are not able to reject our theory[4].

The paper is organized as follows. In the next section we place this paper in the context of the literature on …scal competition. Section 3 describes the main features of the model. Section 4 is devoted to the description of the agents' preferences and to the derivation of a non-cooperative equilibrium. In section 5 we study the harmonization procedure and derive the main results. Section 6 discussed extension of the model.

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from …scal competition on value added tax.

[3] The subsidiarity principle states that decisions have to be taken at the lowest e¢cient level of government (supra national, national or regional).

[4] To check if the correlation is signi…cant we regress the extend of foreign capital ownership divided by the active population on the statutory corporate tax level and found that this coe¢cient is signi…cant at .99.

## 2. Related Literature

Several papers investigate the scope for international income tax coordination. Some of them consider a …xed international remuneration of capital. Razin and Sadka (1991) showed that when there is no pure pro…t and all …scal instruments are available, there is no scope for coordination as each country uses only residency based tax and therefore no international externalities are created by …scal policy. Huizinga and Nielsen (1996) show that there are cases for coordination when some pure pro…t exists. They show that coordination is more important when foreign ownership is developed in each countries.

The largest support for …scal coordination comes from models considering endogenously determined capital remuneration. Bucovetsky and Wilson (1991), Persson and Tabellini (1992), Lopez, Marchand Pestieau (1996) show that …scal competition leads to under-provision of public good or ine¢cient redistribution. Others, like Bucovetsky (1991) and Grazzini and van Ypersele (1996) are concerned about the e¢cient allocation of capital. They therefore consider a …xed public budget requirement. Both show that there is room for coordination.

This paper belongs to the last category. It di¤ers from the existing literature in several ways. First, we allow heterogeneity among countries in size of its population, as in Bucovetsky (1991) and in capital endowment. This leads to an asymmetric equilibrium to the non-cooperative gave and enables us to tackle more carefully the problem of ine¢cient allocation of capital. Second, we consider a setting with an arbitrary numbers of countries. It does not add much to the description of a non-cooperative equilibrium, but provides a richer model with which to consider the di¤erent potential coordination policies. More importantly, we propose design for coordination policies in an environment that could be considered as supranational institutions.

A non negligible aspect of our result, is that, contrary to Bucovetsky and Wilson (1991), …scal coordination holds even when residence based capital tax is allowed.

Our model builds on Grazzini and van Ypersele (1996). The …rst part of our analysis generalizes it by extending the number of countries (from two to N) and by using a more general production function. It enables us to decompose the e¤ect of …scal policies on the welfare of each country in a more precise way. The most interesting innovations lie in the analysis of the tax reform proposition.

## 3. The model

Consider N sovereign countries that run a …scal policy in order to balance their public budget. Each country is assumed to have an exogenously …xed budget re-

quirement $G_i$ [5]. Fiscal policies consist in per unit factor taxes levied according to the source based principle. The economy is described as follows: two production factors, capital K and labor L, are used in the production of a single consumption good. The production technology exhibits constant returns to scale and is described by a homogeneous production function $F(K;L)$: $F(K;L) = Lf(k)$ with $k = K=L$, $f'(k) > 0$ and $f''(k) < 0$. To spare conditions on positive production and positive net remuneration of capital, we also assume that $f'(0) = 1$, $f'(1) = 0$, $f(0) = 0$.

Firms behave competitively and production factors are therefore priced at their marginal productivity:

$$r = f'(k)$$

and

$$w = f(k) - kf'(k)$$

r and w denoting respectively, the gross remuneration of capital and labor. The relative factor demand of a particular …rm is given by:[6]

$$k(r) = f'^{-1}$$

with

$$k' = \frac{1}{f''(k)}:$$

It is assumed that capital is perfectly mobile and labor perfectly immobile. As taxes are levied according to the source based principle, the capital is invested in the country giving the largest net remuneration. The following arbitrage condition holds:

$$r_i - t_i = r_j - t_j = \rho \quad 8i = 1::N$$

where $t_i$ is the per unit capital tax and $\rho$ net capital remuneration on the international market.

Countries are assumed to be asymmetric with respect to their factor endowment and we denote by $K_w$ and $L_w$ the world aggregate endowment of capital and labor and $\lambda_i > 0$ and $\theta_i > 0$; the shares of the aggregate endowment of owned by country i;so that $L_i = \lambda_i L_w$ and $K_i = \theta_i K_w$. Note that $\sum_1 \lambda_i = 1$ and $\sum_1 \theta_i = 1$. For later use, we de…ne $\overline{k}_i = \frac{\overline{K}_i}{\overline{L}_i}$ and $\overline{k}_w = \frac{\overline{K}_w}{\overline{L}_w}$:

At the Walrasian equilibrium, factor prices adjust to clear markets. A labor market exists in each country and international markets are available for the capital and consumption goods. At equilibrium, labor markets clear in each country.

[5] We denote the country variables with a subscript i where i = 1::N.

[6] Subscripts and dependent variables will be omitted when not absolutely necessary.

The international capital market clearing condition is therefore given by

$$L_w^{-1} \sum_i \alpha_i k_i(\rho; t_i) = K_w^{-1}.$$

As the LHS of this equation is strictly decreasing in $\rho$, an equilibrium exists,

$$\rho = \rho(t_1; ...; t_i; ..t_n)$$

with

$$\rho_{t_i} = \frac{\partial \rho}{\partial t_i} = -\frac{\alpha_i \tilde{K}_i'}{\sum_{j=1} \alpha_j \tilde{K}_j'}.$$

At equilibrium the level of capital invested in each country is

$$K_i(\rho(t_1; ...; t_i; ..t_n); t_i) = \alpha_i L_w \tilde{k}_i(\rho(t_1; ...; t_i; ..t_n); t_i)$$

Therefore, the existing equilibrium wage rate is given by

$$w_i = f(\tilde{k}_i) - k_i f'(\tilde{k}_i)$$

with

$$\frac{\partial w_i}{\partial t_i} = -(\varepsilon_{t_i} + 1)\tilde{k}_i < 0$$

for $i = 1...N$, and

$$\frac{\partial w_i}{\partial t_j} = -\rho_{t_j} \tilde{k}_i > 0$$

for $i = 1...N$ and $j \neq i$.

It is important to note that capital movements originate in two sources: the difference in factor endowments and the difference in capital taxes. In the absence of capital taxes, capital movements lead to an equalization of the invested capital labor ratio across countries, i.e. to the efficient allocation of factors. Accordingly, the liberalizing the capital market leads to a better allocation of resources, and capital taxes introduce distortions in the capital market. When capital taxes are not equalized across countries, part of the capital movements are not motivated by allocative efficiency but by fiscal opportunism.

## 4. Fiscal competition

In this section we analyze fiscal competition arising between the different countries. Capital and labor taxes are assumed to be decided simultaneously by each national social planner who maximizes the welfare of its representative consumer.

Tax setting is described as an equilibrium of a non-cooperative game in which strategies are tax levels and the payo¤s which are the countries representative agent's utility. First, we describe the public budget constraint and analyze for each country the e¤ect of its national …scal policy on the welfare of its representative consumer. Then, we characterize a non-cooperative equilibrium of the game we have just described.

### 4.1. The government budget constraint

In country i, a …xed amount of public money, $G_i$; has to be levied through taxation. The …scal choice lies in the allocation of the tax burden between labor and capital. Taxes are per unit and source based[7]. The budget constraint of the government in country i writes as:

$$G_i = \, _i L_w(¿_i + t_i k_i)$$

with $¿_i$ and $t_i$ denoting respectively, labor and capital taxes. Indeed, the …scal decision is essentially a single dimension problem since $¿_i$ can be expressed as a function of $t_i$,

$$¿_i = \frac{G_i}{\, _i L_w} ¡ t_i k_i:$$

It is important to note that the …scal choice consists in levying public money through a non-distortionary tax instrument and/or a distortionary one. The labor tax is non-distortionary as labor is inelastically supplied and immobile while the capital tax distorts the international price of capital.

As no limits have been imposed on the tax instrument, it is possible to have negative taxes at equilibrium.

### 4.2. The representative agent

In this part of the section, we isolate the di¤erent e¤ects of the capital tax on the welfare of the representative agent of a particular country.

The representative agent in country i derives welfare from consumption of the single good produced in the economy. His preferences can be represented by its country's per capita GNP, i.e. the value of the domestic product minus the net contribution from abroad:

$$U_i = (r_i k_i + w_i) ¡ ½(k_i ¡ \bar{k}_i) \qquad (4.1)$$

where $\bar{k}_i = \frac{\overline{K}_i}{\overline{L}_i}$ is the aggregate relative endowment of country i and $k_i = \frac{K_i}{L_i}$ is the ratio of the factors of production e¤ectively invested in country i:

[7] We extend the analysis to the case where both source based and residency based taxes are available to the government.

The marginal effect of capital tax can be decomposed into three effects: the terms of trade effect, the tax import/export effect and the capital movement effect. These are respectively identified in the following expression:

$$\frac{dU_i}{dt_i} = -\frac{d(r(k_i - \bar{k}_i))}{dt_i}\bigg|_{\bar{k}_i} + \frac{d(t_i(k_i - \bar{k}_i))}{dt_i} + (\bar{k}_i - k_i).$$

The terms of trade effect represents the gain (loss) that a capital importing (exporting) country makes resulting from the depression of the international remuneration of capital induced by the increase of the capital tax. We call it the terms of trade effect as the logic behind it is exactly the one that justifies the optimum tariff in international trade : the tariff is seen as a way to influence the terms of trade. A country that imports capital has an incentive to increase its capital tax in order to decrease its cost. On the contrary, a country that is capital exporter should decrease it in order to increase its international remuneration.

The tax burden import/export effect : When a capital importing country levies a tax on capital, not only resident owners pay the tax but also the foreign investors. This means that part of its tax burden is supported by non-residents, i.e. $t_i(k_i - \bar{k}_i)$. By increasing the capital tax level, a capital importing country influences the size of the tax burden that it exports. Up to a certain point this effect is positive. For a capital exporting country, the reverse is observed: each unit of exported capital is not taxed at home and is then a loss of tax revenue.

The residual effect of the fiscal policy is due to the influence of the induced capital movement on the gross remuneration of factors. A higher $t_i$ decreases invested capital and then changes gross factor remuneration. We call it the capital movement effect. This effect is negative (res. positive) if the country is a capital importer (res. exporter). The logic behind it is that $\frac{dw}{dk} = -k_i\frac{dr}{dk}$: an additional unit of capital invested at home increases a labor remuneration more than capital remuneration when the country is a capital importer.

In order to spare tedious calculations, it is assumed that the utility functions are continuous, strictly quasi-concave with respect to their capital tax rate and that $\frac{\partial^2 U_i}{\partial t_i \partial t_j} \neq 0$: We present in the appendix an example satisfying all these assumptions.

### 4.3. The non-cooperative fiscal decision

It is now possible to describe formally a non-cooperative game played by the different countries. It is a N player game whose players are the national social planners and strategies the level of capital tax.

The payoffs of the game are

$$¼_i(t_1;:::;t_N) = \bar{k}_i½(t_1;:::;t_N) + w(t_1;:::;t_N) + t_i k_i(t_1;:::;t_N) \qquad (4.2)$$

$8i = 1;:::;N$. The strategies are

$$t_i \in [\,¡\,1\,;\,1\,]\ 8i = 1;:::;N: \qquad (4.3)$$

The best reply function of country i, $\mathbf{e}_i(t_{¡\,i})$ is implicitly de…ned by the F.O.C of the maximization problem of its social planner:

$$(1 + ½_{t_i})k_i^0 t_i + (\bar{k}_i\ ¡\ k_i)½_{t_i} = 0; \qquad (4.4)$$

which is equivalent to

$$t_i = \ ¡\frac{½_{t_i}}{1 + ½_{t_i}}\frac{(\bar{k}_i\ ¡\ k_i)}{k_i^0}: \qquad (4.5)$$

By the implicit function theorem, and the assumptions on the utility functions,

$$\frac{@\mathbf{e}_i}{@t_j} = \ ¡\frac{@^2U_i=@t_j@t_i}{@^2U_i=@t_i^2} > 0: \qquad (4.6)$$

This is to say that capital taxes are strategic complements. An equilibrium of the non-cooperative game is given by the solution of the system of equations de…ned by the N best-reply functions de…ned by (4.5).

Proposition 4.1. (i) The game de…ned by equations (4.2) and (4.3) has a non-cooperative equilibrium $(t_1^{nc};:::;t_N^{nc})$. (ii) The equilibrium capital tax levels are such that capital importing countries set positive capital taxes while capital exporting countries subsidize it. (iii)Moreover, at equilibrium, the capital is almost never e¢ciently allocated among countries.

Proof. : (ii) We know that, at equilibrium, countries are on their best-reply functions, this is to say that $t_i = \ ¡\frac{½_{t_i}}{1+½_{t_i}}\frac{(\bar{k}_i\ ¡\ k_i)}{k_i^0}$: $t_i \ \lessgtr\ 0$ when $(\bar{k}_i\ ¡\ k_i) \ \lessgtr\ 0$:

(i)Such game has an equilibrium when payo¤ functions are continuous and quasi-concave and when the strategy sets are compact and convex. As the two …rst conditions are assumptions of our model, we need to show that strategy sets are convex and compact. As capital tax rates are unidimensional strategy sets, we have to show that they are bounded from below and from above. The demonstration is done by contradiction for the upper bound. Imagine that a country, i; sets an in…nite tax at equilibrium, then $r_i = 1$ and, by the assumptions on the production function, $k_i = 0$ and therefore the country is exporting capital. This is impossible as we showed in (ii) that only capital importing countries set

positive capital tax. Following a similar argument, it is easy to show that the strategy sets are bounded from below.

(iii) The capital is e¢ciently allocated across countries when its cost is equalized. As the cost is given by the international price of capital plus the national capital tax rate, costs are equalized only when all countries set the same level of capital tax. This is the case only when countries are symmetric. ■

Even if at a …rst sight, the result could seem surprising, proposition 4:1 is rather intuitive when analyzed with the three e¤ects of capital taxation in mind.

When the capital tax is not too high, capital taxation has two positive e¤ects on welfare for a capital importing country: a decrease in their capital import bill via the terms-of-trade e¤ect and an alleviation of the tax burden via the tax burden export e¤ect. Only the capital movement e¤ect bridles the capital taxation willingness of these countries. Capital taxation has the opposite results for a capital exporting country. They have a negative incentive to tax as they fear a loss of their tax base and they want to get the highest return from the capital they export.

Note here that the ine¢ciencies identi…ed in this proposition would not exist if countries were symmetric in their relative capital endowment. In this latter case, at equilibrium, capital is taxed in none of the countries and thus there does not exist any ine¢ciency in the capital market. In this paper it is the asymmetry between countries that causes ine¢ciency and not the factor elasticity as in Bucovetsky and Wilson (1991) or Huizinga and Nielsen (1996).

As at a non-cooperative equilibrium the allocation of capital is ine¢cient, it makes sense to explore possible coordination devices.

## 5. Fiscal Reforms

We analyze in this section two tax reforms: the minimum tax reform and the tax range reform.

For simplicity, we concentrate our analysis on cases where the equilibrium of the non cooperative game is unique. For further references, label the countries such that $t_1^{nc}$ $t_2^{nc}$::: $t_N^{nc}$ with $t^{nc}$ denoting the value of the taxes at the non-cooperative equilibrium:

### 5.1. The minimum tax reform

The minimum tax reform is a natural candidate as a possible tax reform since it has already been used to overcome ine¢ciencies arising from …scal competition on the VAT in European Union.

In this section, we argue that, under the assumptions of our model, this reform cannot be accepted by all countries. The capital exporting countries reject it while the capital importing countries advocate it. To show this we …rst have to derive the Nash equilibrium of the game where the agents strategies are constrained from below. We de…ne this game as the "tax constrained game". We then show that any increase of the minimum tax level injures the capital exporting countries.

Strategies of this constrained game are all the capital tax levels larger than the minimum tax level, $\underline{t}$; and the payo¤s, the welfare of the representative consumer in each country. Let de…ne $B(\underline{t})$as the set of countries bounded when the minimum tax level is $\underline{t}$ and $\bar{}(\underline{t})$ the largest country index of $B(\underline{t})$.

Lemma 5.1. The "tax constrained" game has an equilibrium $(t^e_1(\underline{t}); :::t^e_i(\underline{t}); ::t^e_N(\underline{t}))$, where $t^e_i(\underline{t}) = \underline{t}$ for $i \quad \bar{}(\underline{t})$ and $\frac{dt^e_i(\underline{t})}{d\underline{t}} > 0$ for $i > \bar{}(\underline{t})$.

Proof. As strategy sets are compact and convex and payo¤s are quasi-concave and continuous functions, the equilibrium exists. The equilibrium taxes are increasing functions of the minimum tax level because they are strategic complements as shown in (4.6). ■

This shows that for each level of the minimum tax rate, an equilibrium exists. Let us now state the following proposition:

Proposition 5.2. The minimum tax reform is never unanimously accepted.

Proof. As a reform passes only if it is weakly preferred by all countries and strictly preferred by at least one, it is enough to show that an increase of $\underline{t}$ is detrimental for at least one country. We do this for a non-constrained country.

By di¤erentiating the welfare of an agent i at the constrained equilibrium $(t^e_1(\underline{t}); :::t^e_i(\underline{t}); ::t^e_N(\underline{t}))$ with respect to $\underline{t}$

$$\frac{dU_i}{d\underline{t}} = \frac{dU_i}{dt^c_i}\frac{dt^c_i}{d\underline{t}} + \sum_{j \neq i} \frac{dU_i}{dt^c_j}\frac{dt^c_j}{d\underline{t}} \tag{5.1}$$

As country i is not constrained, it is on its best reply and thus $\frac{dU_i}{dt^c_i} = 0$. Moreover,

$$\frac{dU_i}{dt^c_j} = \frac{1}{2}t_j \frac{(k_i - k_i)}{1 + \frac{1}{2}t_i}$$

Then,

$$\frac{dU_i}{d\underline{t}} = \frac{(k_i - k_i)}{1 + \frac{1}{2}t_i} \sum_{j=1} \frac{1}{2}t_j \frac{dt_j}{d\underline{t}} \tag{5.2}$$

This expression is negative (res. positive) when the country i exports (reps. imports) capital. There is a con‡ict of interest between the capital importing countries and the capital exporting ones. For completeness, we have to consider the case where none of the capital exporting countries are unbounded. To see that it is also detrimental for a bounded country, just note that this country is forced to set a capital tax larger than its optimal one. This means that $\frac{dU_i}{dt_i^c} < 0$; knowing that $\sum_{j \neq i} \frac{dU_i}{dt_j^c}\frac{dt_j^c}{d\underline{\pm}} = \frac{(\bar{k}_i - k_i)}{1+\frac{1}{2}t_i} \sum_{j=1} \frac{1}{2}t_j \frac{dt_j}{d\underline{\pm}}$, by 5.1 it is straightforward that $\frac{dU_i}{d\underline{\pm}} < 0$: ■

A rough intuition of this result is the following. As it is for the capital exporting countries that the minimum tax could be binding, bounded countries have to give up more of their tax base than they would like. This is detrimental for them and positive for the capital importing countries that have the opportunity to export more of their tax burden.

In our model, this means that if the European Union wants to pass this kind of reform, capital exporting countries have to be compensated. Even if this is not impossible, it is nevertheless interesting to …nd another tax reform that would be self contained. This is what is developed in the next section.

## 5.2. The tax range reform

A tax range reform is de…ned as the imposition of a lower ($\underline{\pm}$) and an upper ($\bar{\pm}$) limit to the capital tax level. The tax range is given by $[\underline{\pm}; \bar{\pm}]$.

We show that there exist such tax reforms that are unanimously preferred to the non-cooperative equilibrium. The success of this reform precisely comes from the weakness of the former one. If it is detrimental for the capital exporting countries to be bound from below and positive for the capital importing, it is reasonable to expect the opposite e¤ect from an upper boundary. As both policies decrease the inter-country di¤erence in capital cost, it improves the capital allocation e¢ciency. We can therefore expect a net gain from the combination of these two reforms.

As for the minimum tax reform, we …rst compute the constrained Nash equilibrium. We then show that it can be Pareto improving.

The constrained Nash equilibrium is de…ned by the game which strategies are all the capital tax levels in the tax range, $[\underline{\pm}; \bar{\pm}]$ and the payo¤s are the welfare of each representative consumer.

For a given tax range, de…ne $B(\underline{\pm}; \bar{\pm})$ as the set of countries that are bounded from below and $T(\underline{\pm}; \bar{\pm})$ as the set of countries bounded from the top.

Let also de…ne $\bar{\imath}(\underline{\pm}; \bar{\pm}) = 1 + \max_i B(\underline{\pm}; \bar{\pm})$ and $\mu(\underline{\pm}; \bar{\pm}) = \min_i T(\underline{\pm}; \bar{\pm}) - 1$: $\bar{\imath}$ is then the index of the unbound country with the lowest capital tax and $\mu$ is the index of the unbound country with the highest capital tax.

Lemma 5.3. : This game has an equilibrium $(t^{c}_{1};:::t^{c}_{i};::t^{c}_{N})$, where $t^{c}_{i} = \underline{\pm}$ when $i < \underline{\mu}(\underline{\pm};\bar{\pm})$, $t^{c}_{i} = \bar{\pm}$ for $i \geq \mu(\underline{\pm};\bar{\pm})$ and $t^{c}_{i} = t^{c}_{i}(\underline{\pm};\bar{\pm})$ when $\underline{\mu}(\underline{\pm};\bar{\pm}) < i < \mu(\underline{\pm};\bar{\pm})$: Where $\frac{dt^{C}}{d\underline{\pm}} > 0$ and $\frac{dt^{C}}{d\bar{\pm}} > 0$.

Proof. By the usual argument, the existence of the equilibrium is ensured. As capital taxes are strategic complements, $\frac{dt^{C}}{d\underline{\pm}} > 0$ and $\frac{dt^{C}}{d\bar{\pm}} > 0$: ■

Each tax range corresponds to a constrained Nash equilibrium. We now turn to the analysis of impact of a tax range reform $d\underline{\pm}$, $d\bar{\pm}$ on the welfare of the different representative agents.

A country bounded from below, i.e. $i < \underline{\mu}$, has the following welfare function

$$U_i = \rho\bar{k}_i + w_i + \underline{\pm}k_i$$

Differentiating it with respect to $\underline{\pm}$, we get the welfare effect of an increase of the lower bound,

$$\frac{dU_i}{d\underline{\pm}} = \frac{d\rho}{d\underline{\pm}}(\bar{k}_i - k_i) + \underline{\pm}\dot{k}_i\,(1 + \frac{d\rho}{d\underline{\pm}})$$

Similarly, for the upper bound,

$$\frac{dU_i}{d\bar{\pm}} = \frac{d\rho}{d\bar{\pm}}(\bar{k}_i - k_i) + \underline{\pm}\dot{k}_i\,\frac{d\rho}{d\bar{\pm}}$$

The total effect is given by,

$$dU_i = \frac{dU_i}{d\underline{\pm}}d\underline{\pm} + \frac{dU_i}{d\bar{\pm}}d\bar{\pm} = \underline{\pm}\dot{k}_i\,d\underline{\pm} + (\frac{d\rho}{d\underline{\pm}}d\underline{\pm} + \frac{d\rho}{d\bar{\pm}}d\bar{\pm})(\bar{k}_i - k_i + \underline{\pm}\dot{k}_i): \qquad (5.3)$$

By exactly the same procedure it is easy to show that, for countries bounded from above,

$$dU_i = \frac{dU_i}{d\underline{\pm}}d\underline{\pm} + \frac{dU_i}{d\bar{\pm}}d\bar{\pm} = \bar{\pm}\dot{k}_i\,d\bar{\pm} + (\frac{d\rho}{d\underline{\pm}}d\underline{\pm} + \frac{d\rho}{d\bar{\pm}}d\bar{\pm})(\bar{k}_i - k_i + \bar{\pm}\dot{k}_i). \qquad (5.4)$$

The welfare effect of a tax range reform on an unbounded country is a little more difficult to find.

The welfare of an unbounded country is given by

$$U_i = \rho\bar{k}_i + w_i + \underline{\pm}^{c}_{i}(\underline{\pm};\bar{\pm})k_i$$

Di¤erentiating with respect to both boundaries, we get

$$\frac{dU_i}{d\pm} = (\overset{1}{k}_i \; ¡ \; k_i)\frac{d½}{d\pm} + t_i \overset{\cdot}{k}_i \left(\frac{dt_i}{d\pm} + \frac{d½}{d\pm}\right)$$

with $\pm = \underline{\pm}; \overline{\pm}$:

The total e¤ect of the reform is then

$$dU_i = (\overset{1}{k}_i \; ¡ \; k_i + t_i \overset{\cdot}{k}_i)d½ + t_i \overset{\cdot}{k}_i \, dt_i \tag{5.5}$$

with $dx = \frac{dx}{d\underline{\pm}} d\underline{\pm} + \frac{dx}{d\overline{\pm}} d\overline{\pm}$:

It is now possible to show the following proposition.

**Proposition 5.4.** *Tax range reforms that leave international remuneration of capital unchanged and increase the elasticity of the international demand for capital exist and are always accepted as long as* $d\underline{\pm} > 0$, $d\overline{\pm} < 0$ *and* $0 \; 2 \; \pm; \overline{\pm}$. *Moreover, as a result of the tax reform, all capital exporting countries increase their capital tax and all capital importing ones decrease it.*

**Proof.** From (5.3), (5.4) and (5.5), it directly follows that

when $i < \underline{\mu}$;

$$dU_i = \underline{\pm} \overset{\cdot}{k}_i \, d\underline{\pm} \; ¸ \; 0 \text{ as long as } d\underline{\pm} > 0 \text{ and } \underline{\pm} \quad 0;$$

and, when $i > \mu$;

$$dU_i = \overline{\pm} \overset{\cdot}{k}_i \, d\overline{\pm} \; ¸ \; 0 \text{ as long as } d\overline{\pm} < 0 \text{ and } \overline{\pm} \; ¸ \; 0;$$

where the conditions on the boundaries and on the reforms are equivalent to the one stated in the proposition;

when $i \; 2 \; [\underline{\mu}; \mu]$;

$$dU_i = t_i \overset{\cdot}{k}_i \, dt_i;$$

As by setting $t^{\mathbb{C}}_i$ equal to its capital tax before the reform, unbounded countries can secure the before reform welfare, if they change their equilibrium strategy, it is for the better. This is to say that $dU_i > 0$ and by the former equation that $dt_i \; ¸ \; (\quad)0$ when country $i$ is capital exporter (importer)

This says that under these conditions, all countries are better o¤. The reform then passes.

To complete the proof, we have to show that such reform exists and increases the elasticity of the international demand for capital.

■

The intuition behind this result is the following.

As ½ is unchanged, the term of trade e¤ect on welfare is neutralized. A tax range reform is a mix between a minimum tax increase and a maximum tax decrease. An increase of the minimum tax hurts capital exporting countries, because of the tax burden e¤ect, as they are forced to give up more than they would like of their tax base. This e¤ect is however attenuated by the increase of their gross income described by the capital movement e¤ect. The capital importing countries are a¤ected exactly in the opposite way. They are able to export more of their tax burden but have to pay a tribute, the decrease of their gross income. The decrease of the maximum tax a¤ects countries in exactly the opposite way. The tax burden e¤ect is used as a built-in mechanism to transfer resources from the country that gains to compensate the countries su¤ers. Capital exporting countries bene…t from the e¢ciency gain and compensate the capital importing.

The e¢ciency gains are larger than the one directly created by the convergence of the boundaries: there are gains due to the additional convergence of the countries that are not bounded by the reform. This additional convergence is explained by the increased elasticity of the international demand for capital: all capital importing (exporting) countries have an incentive to increase (decrease) their capital tax because the terms of trade e¤ect is augmented (On the welfare point of view, the term of trade e¤ects are neutralized, but the marginal e¤ect of capital tax described by the term of trade e¤ect is a¤ected). This induces a further convergence of the capital taxes and thus an additional increase of e¢ciency.

In this proposition, the zero capital tax rate seems to be important, which is not surprising since labor tax is non-distortionary. We can reasonably conjecture that if labor supply were inelastic, a positive capital tax rate would play this role.

Both reforms have the appealing properties of being simple, anonymous and respecting the subsidiary principle. By anonymous we mean that the minimum tax or the range applies in the same way to all countries, i.e. it restricts their strategy set. A non anonymous reform would impose a di¤erent tax level on each country. In the context of our model it does not make a big di¤erence. A minimum tax or tax range reform is mimicked by imposing to each country the capital tax level that they would have announced under the minimum tax reform or the tax range reform. An anonymous rule is desirable because: (i) The informational requirement in imposing such reforms is lower, and (ii) a non anonymous reform would be politically di¢cult to sustain.

The proposed reforms respect the subsidiary principle as they leave to the national level the …scal decision while the supra-national interventions intend to limit ine¢ciencies.

A more ambitious way of interpreting this work is to see it as an attempt to design supra-national (for Europe) or federal (for Australia, Canada or the US) institutions helping to avoid the ine¢ciencies linked to …scal competition.

An institution consists in competencies and a decision rule. The competencies would be the setting of the tax range. For the decision rule, we propose unanimity rule as it prevails in the European Union on these matters or with the behavior of independent countries in international negotiations. Some of the required features of such institution would be precisely to respect the anonymity and the subsidiary principles. For instance, the WTO, with its most preferred clause, imposes that each country grant an equal treatment to all their trade partners.

## 6. Additional discussion

It is important to note that in this paper, the source based capital tax would be used even if a residency base version would be at the disposition of the government. The existence of a residency based tax would only enable the government to reallocate part of the tax burden from the workers to the capital owners. The source based capital tax would still be used as a strategic device.

We want to discuss the following extension: Imagine that the three tax instruments were available and that factor supplies are not perfectly inelastic (but quite). The conclusions of our model would not be changed, the non-cooperative equilibrium would consists in source based and residency based taxes and a labor tax for each country. The source based capital tax wouldn't have changed as factor supply are quite inelastic. But the residual tax burden would be split among the capital income and the labor residency based taxes to minimize the distortions due to the factor supply elasticity.

Imagine now, that tax evasion is possible and is done at no risk. To evade tax at no risk, a capital owner has to get the income of its capital from a non-national institution. For instance, the Belgian capital owner gets its dividend from a Luxembourg bank even though his capital is invested in Belgium. The residency based tax would then be nil as it is not possible to implement it. In this case, the introduction of a minimum withholding tax would please all countries as it enables the government to use this instrument at least up to the minimum tax level and therefore enable to decrease the ine¢ciencies linked to the factor supply elasticity. Typically, the minimum withholding tax would be the lowest one from set of the nationally preferred residency based capital without tax evasion.

The introduction of a minimum capital tax would pass without doubt. To reach this conclusion, it has to be assumed that no pro…t is done by the banks distributing the bene…ts and no risk are taken by the tax evaders. This is typically not the case. This explains that we observe a certain level of residency based capital tax in Europe and that countries that attract the most of these …nancial bene…ts try to block this kind of reforms.

## 7. Conclusion

In this paper we have analyzed …scal competition between N asymmetric countries when international capital market is liberalized. We have concentrated our analysis on the e¤ect of this competition on the allocation of capital among countries, i.e. on production e¢ciency. We decompose the impact of …scal policy in three e¤ects: the terms of trade e¤ect, the tax import/export e¤ect and the capital movement e¤ect.

We have shown that, when countries behave non-cooperatively, at equilibrium, capital tax level di¤ers among countries leading to an ine¢cient allocation of resources. We examined two tax reforms, one that imposes a minimum tax and another that …xes a range in which capital tax levels have to be decided.

We showed that the …rst reform would not be unanimously accepted and that the second reform passes as long as the convergence of tax limits is such that the international remuneration of capital is not a¤ected. The N countries framework is important here, as the e¤ects of the reforms di¤ers from countries that are bounded and the one that are unbounded.

We argued that the tax range reform plus the unanimity rule could be an interesting starting point for discussion of a supranational or federal …scal institution as it respects some appealing principles like the anonymity of the reforms and the subsidiary principle.

This paper helps to identify how asymmetry between a large number of countries plays an important role in the …scal competition and what kind of reforms could pass. In addition to that it allows for several interesting extensions on the economical and institutional points of view.

## 8. Appendix

In this appendix, considering a particular example, we show, with some lemmas, that the analysis we undertook in this paper is not vain, i.e. we were not reasoning on an empty set.

Consider the following constant returns to scale production function in intensive form:

$$f(k) = (a - bk)k$$

This function has been used by Bucovetsky and Grazzini and van Ypersele. It perfectly …ts in the assumptions we impose except for two technical conditions i.e. $f'(0) = 1$, $f'(1) = 0$. These conditions have to be replaced by $\overline{k}_i < \frac{a}{2b^\circ_i}$; in order to ensure positive marginal productivity.

Lemma 0.1. $\frac{d^2U_i}{dt_i^2} < 0$ and $\frac{d^2U_i}{dt_j\,dt_i} > 0$:

Proof. Mutatis mutandis equation (4.4),

$$\frac{dU_i}{dt_i} = 2b_{,i}(\overline{k}_w - \overline{k}_i) + \circ_i \sum_{j=1}^{N} {}_{,j}t_j - t_i = 0 \qquad (0.1)$$

It directly follows that $\frac{d^2U_i}{dt_i^2} = (_{,i}^2 - 1) < 0$ and $\frac{d^2U_i}{dt_j\,dt_i} = {}_{,j}{}_{,i} > 0$. ■

Lemma 0.2. The non-cooperative equilibrium exists and is unique.

Proof. The Nash equilibrium solves the system of equations de…ned by (0.1) for the N countries. This system is linear and of full rank. The solution is then unique given by

$$t_i^{nc} = 2bk_w \left( {}_{,i} \frac{1 - \sum_{j=1} \circ_{j\,,j}}{1 - \sum_{j=1} {}_{,j}^2} - \circ_i \right) \quad for all i = 1:::N$$

■

Lemma 0.3. For all tax range $[\underline{\pm}; \overline{\pm}]$; an equilibrium of the constrained game exists and is unique.

Proof. The equilibrium of the constrained game solves the system of equations of the non-constrained countries: is unique, as this is a non-homogeneous system of equations.

$$e_i(t_{-i}) = \frac{_{,i}}{1 - {}_{,i}^2} \left( 2b\overline{k}_w(1 - \frac{\circ_i}{_{,i}}) + \underline{\pm} \sum_{j=1}^{\overline{x}} {}_{,j} + \overline{\pm} \sum_{j=\mu}^{N} {}_{,j} + \sum_{j=-}^{x} {}_{,j}t_j \right)$$

In matrix form,

$$\begin{bmatrix} 1 & -\frac{_{,-}}{1+_{,-}}{}_{,-+1} & \cdots & -\frac{_{,-}}{1+_{,-}}{}_{,\mu} \\ -\frac{_{,-+1}}{1+_{,-+1}}{}_{,-} & 1 & \cdots & \\ \cdots & \cdots & & \\ -\frac{_{,\mu}}{1+_{,\mu}}{}_{,-} & \cdots & & 1 \end{bmatrix} \begin{bmatrix} t_- \\ t_{-+1} \\ \cdots \\ t_\mu \end{bmatrix} = \begin{bmatrix} \frac{_{,-}}{1-{}_{,-}^2}A_- \\ \frac{_{,-+1}}{1-{}_{,-+1}^2}A_{-+1} \\ \cdots \\ \frac{_{,\mu}}{1-{}_{,\mu}^2}A_\mu \end{bmatrix}$$

with $A_i = 2b\overline{k}_w(1 - \frac{\circ_i}{_{,i}}) + \underline{\pm} \sum_{j=1}^{-(\underline{\pm};\overline{\pm})} {}_{,j} + \overline{\pm} \sum_{j=\mu(\underline{\pm};\overline{\pm})} {}_{,j}$

Applying Cramer's rule and standard matrix calculus results, we get

$$t_i^C = \frac{\tau_i\left(\sum_{j=\underline{\alpha}+i}^{\mu} A_j \tau_j^2 - A_i \tau_j^2\left(\sum_{j=\underline{\alpha}+i}^{\mu} \tau_j^2 - 1\right)\right)}{1 - \sum_{j=\underline{\alpha}+1}^{\mu} \tau_j^2} \text{ for all } i \text{ such that } \underline{\alpha} \leq i \leq \mu$$

and

$$t_i^C = \underline{t} \text{ for all } i < \underline{\alpha} \text{ and } t_i^C = \overline{t} \text{ for all } i > \mu.$$

■

Lemma 0.4. There exists at least one pair of countries $(i;j)$ such that $\text{sign}(1 + \sum_{l=\underline{\alpha}}^{\mu} \frac{1}{2} t_l a_l - \frac{1}{2} t_i a_i)(\overline{k}_i - k_i) \neq \text{sign}(1 + \sum_{l=\underline{\alpha}}^{\mu} \frac{1}{2} t_l a_l - \frac{1}{2} t_j a_j)(\overline{k}_j - k_j)$.

Proof. To prove this we first compute $a_i$ and show that $1 + \sum_{l=\underline{\alpha}}^{\mu} \frac{1}{2} t_l a_l - \frac{1}{2} t_i a_i$ has the same sign for all countries which is a sufficient condition for the statement of the lemma as $\overline{k}_i - k_i$ does not have the same sign for all countries.

$$dt_i = a_i\left(d\underline{t}\frac{\partial \frac{1}{2}}{\partial \underline{t}} + d\overline{t}\frac{\partial \frac{1}{2}}{\partial \overline{t}}\right) = \left(d\underline{t}\sum_{j=1}^{\underline{\alpha}} \tau_j + d\overline{t}\sum_{j=\mu}^{N} \tau_i\right) a_i.$$

with $a_i = \tau_i \frac{1}{1 - \sum_{j=\underline{\alpha}}^{\mu} \tau_j^2}$.

It is now possible to check if $1 + \sum_{j=\underline{\alpha}}^{\mu} \frac{1}{2} t_j a_j - \frac{1}{2} t_i a_i$ has the same sign for all countries[8].

$$1 + \sum_{j=\underline{\alpha}}^{N} \frac{1}{2} t_j a_j - \frac{1}{2} t_i a_i = 1 + \frac{1}{1 - \sum_{j=\underline{\alpha}}^{\mu} \tau_j^2}\sum_{j=\underline{\alpha}}^{\mu} \tau_j^2 - \frac{1}{1 - \sum_{j=\underline{\alpha}}^{\mu} \tau_j^2} \tau_i^2 > 0$$

as $\sum_{j=\underline{\alpha}}^{\mu} \tau_j^2 < 1$. ■

[8] This is a sufficient condition to ensure that there exist at least one pair of countries $(i;j)$ such that $\text{sign}(1 + \sum_{l=\underline{\alpha}}^{\mu} \frac{1}{2} t_l a_l - \frac{1}{2} t_i a_i)(\overline{k}_i - k_i) \neq \text{sign}(1 + \sum_{l=\underline{\alpha}}^{\mu} \frac{1}{2} t_l a_l - \frac{1}{2} t_j a_j)(\overline{k}_j - k_j)$.

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